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QoS measurement of video service in overlay multicast

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ABSTRACT

As more applications of video and audio to be used more researches QoS measurement of multicast are being done nowadays. Even more experiments which are done at the international research network are more important than before. In this paper we use overlay multicast technology to construct a test-bed with overlay multicast relay (OMR) over international research network. We do multicast QoS experiments in the test-bed with international research network and make analysis and comparison. Through these research works, we get different kind of performance valuation of multicast in international research network. We propose QoS measurement method of multicast video service in the international research network.

Key words: Overlay Multicast; IPTV; QoS; KOREN; TEIN3

INTRODUCTION

For mission-critical operations, providing consistent and superlative QoS (quality of service) is a critical requirement for any IT organization. Whether you work in telecommunications, enterprise networking or other high-traffic environments, QoS management relies significantly not only a superior messaging infrastructure that allows distributed applications with a variety of systems to easily and reliably communicate with one another, but also a proven application infrastructure that delivers superior security, performance, and reliability in systems management. Such an infrastructure is crucial to QoS management in maintaining consistent communication with your business partners, facilitating the secure exchange of information outside the firewall, ensuring continuity of communication during scheduled downtime, and protecting against data loss in the event of a system crash [5].

Otherwise the multimedia such as audio and video are going to the IP network. However, there still are some problems which are not solved very well. QoS is the one of the major problems of multimedia. "Best-effort" delivery of TCP/IP can make the real time application service to appear delay jitter, high packet loss rate, then the real time service will be reduced its effectiveness. Therefore the feasible, efficiency QoS management based IP network is a hot issue.

Multicast over international research network is being more and more important for IPTV services. Although there is no problem for LAN multicast anymore but there are many indeterminacy reasons in international research network environment. Therefore in this paper we do the test of multicast in international research network and there will be analysis and comparison of the multicast performance.

In this paper we use RTP (Real-time Transfer Protocol) [11] sequence number for QoS measurement. There will be RTCP (RTP control Protocol) [12] protocol for monitoring and controlling the real-time data.

There is the related work and background in the second section. We will explain the international research networks

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that are KOREN in Korea and TEIN3 in the second section. The third part, we will mention the test-bed of the system called overlay multicast system. And we will talk about the experiment process and performance valuation of multicast in international research network in the fourth section. The conclusion and future works will be explain in the last section.

RELATED WORK AND BACKGROUND

1. KOREN (Korea Advanced Research Network)

KOREN [6] is a non-profit test-bed network infrastructure established for facilitating R&D and international joint research cooperation. It provides high quality broadband network test-bed for domestic and international research activities into the industry, academia, and research institutions, enabling testing of future network technologies and supporting R&D on advanced applications. KOREN enables internetworking and field testing, which cannot be performed over commercial networks - KOREN enables validation research on high-capacity application services - KOREN reduces R&D cost for researchers including provision of free Gbps - range network connection service - KOREN enables international research cooperation through internetworking with international research networks - KOREN is the only research test-bed network that allows high-capacity traffic solely for testing purposes [30].

2. TEIN3 (Trans-Eurasia Information Network)

TEIN3 (The third generation of the Trans-Eurasia Information Network) [7] provides a dedicated high-capacity Internet network for research and education communities across Asia-Pacific. TEIN3 already connects researchers and academics in China, India, Indonesia, Japan, Korea, Laos, Malaysia, Nepal, Pakistan, the Philippines, Singapore, Sri Lanka, Taiwan, Thailand, Vietnam and Australia. Bangladesh, Bhutan and Cambodia are in the process of getting connected, bringing the total number of partners involved in TEIN3 to 19 [7].

With direct connectivity to Europe's GÉANT [8] network, TEIN3 offers Asia-Pacific a gateway for global collaboration, enabling over 45 million users at more than 8000 research and academic centre to participate in joint projects with their peers in Europe and other parts of the world [7].

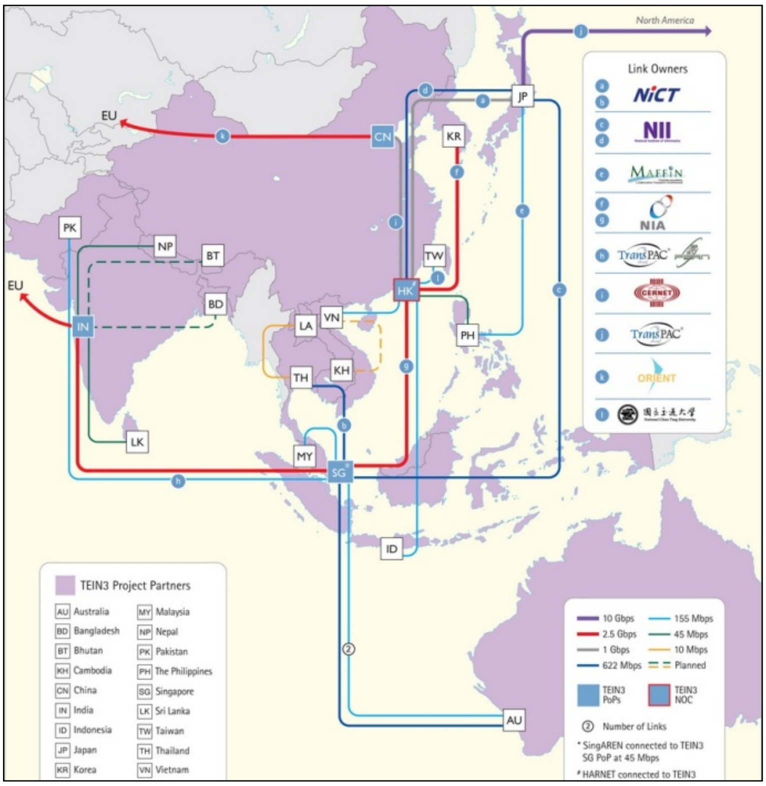

Fig. 1: TEIN3 network [7]

TEIN3 comprises four network hubs in Beijing, Hong Kong, Mumbai and Singapore, connected to GÉANT in Europe via high-speed links on northern overland and southern sea-cable routes. A fifth TEIN3 hub in Tokyo is managed by APAN-JP. In addition, TransPAC2 provides transit for TEIN3 partners with North America. A significant amount of the network capacity is generously provided by TEIN3 partners as illustrated in the map. The remainder has been procured directly through the TEIN3 project.

The TEIN3 network is managed by Tsinghua University from a purpose-built NOC (network operations centre) in Hong Kong.

3. Overlay Multicast

Overlay multicast networks offer an intermediate option, potentially combining the flexibility and advanced features of application layer multicast with the greater efficiency of network layer multicast. Overlay multicast networks play an important role in the Internet. Indeed, since Internet Service Providers have been slow to enable IP multicast in their networks, Internet multicast is widely available as only an overlay service.

Overlay multicast networks mechanism provide multicast services through a set of distributed Multicast Service Nodes (MSN), which communicate with hosts and with each other using standard unicast mechanisms. Overlay networks effectively use the internet as a lower level infrastructure, to provide higher level services to end users.

The multicast backbone, Mbone, is the best known multicast overlay network, but multicast services are also a part of commercial overlay network services, such as Akamai [9] and iBeam [10].

QOS MEASUREMENT TEST-BED FOR MULTICASTING

Before introducing the system, we will talk about the overlay multicast test-bed structure in this section. Because of that the overlay multicast streaming can be received through the international research network at the same time with several clients. So, using the overlay multicast system, we can get more exactly QoS measurement result.

Another benefit of using overlay multicast is that we can change the source video as real-time streaming or video files what we need. For example we can make video streaming with high quality camera or video file.

The test-bed we had is mainly consists of two parts as shown in Figure 2. The first part is root side and the second one is edge side. There is a root OMR (overlay multicast relay) in the root side and an edge OMR in the edge side. For example in the Figure 2 the root OMR is in the local network of Local A and the edge OMR is in the local network of Local B.

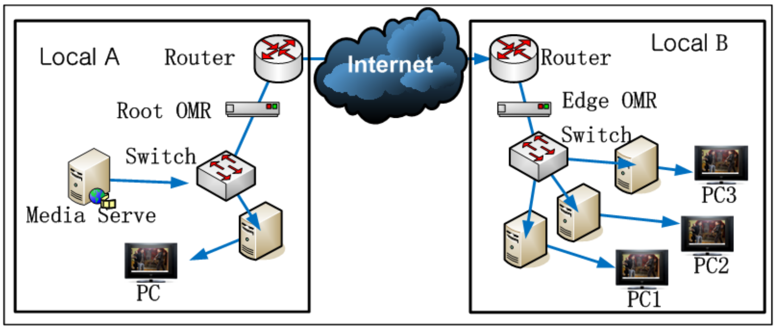

Fig. 2: Overlay multicast testbed

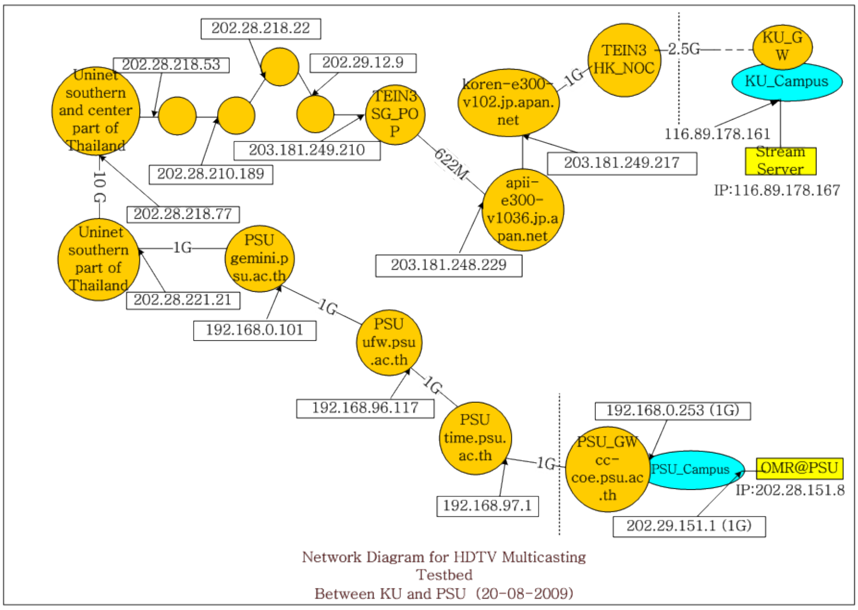

Fig. 3: Network Diagram of KOREN-TEIN3-ThaiREN

Real-time multicast streaming by media server in Local A part will be forwarded to root OMR through its local switch, root OMR will change the multicast streaming to unicast streaming and then forward the stream to edge OMR which is in the local B, the PC in Local A can check the multicast streaming which is sent from Media Server, then the edge OMR will change the streaming to multicast streaming again, and forward them into Local B. So the PC1, PC2 and PC3 which are in Local B can receive the same multicast streaming at the same time. Therefore we can get the same multicast purpose in the international research network.

We use ping command to get the network diagram at the same time with overlay multicast streaming as shown in Figure 3 which is from KU (Konkuk University) in Korea in KOREN network to PSU (Prince of Songkla University) in Thailand through TEIN3 network, it records that every router IP address and how many routers that the packet has traversed. It also records the network bandwidth among every hop.

Although there are several paths between Korea to Thailandbut the data in this test-bed is going through KR-HK-JP-SG-TH. The bandwidth of path got for the test-bed is that KR-HK 2.5Gbps, HK-JP 1Gbps, JP-SG 622Mbps, SG-TH 622Mbps, and the bandwidth inside of ThaiREN is also shown in Figure 3.

We construct the overlay multicast test-bed between KU and PSU with ThaiREN [13], TEIN3 and KOREN network as shown in Figure 4.

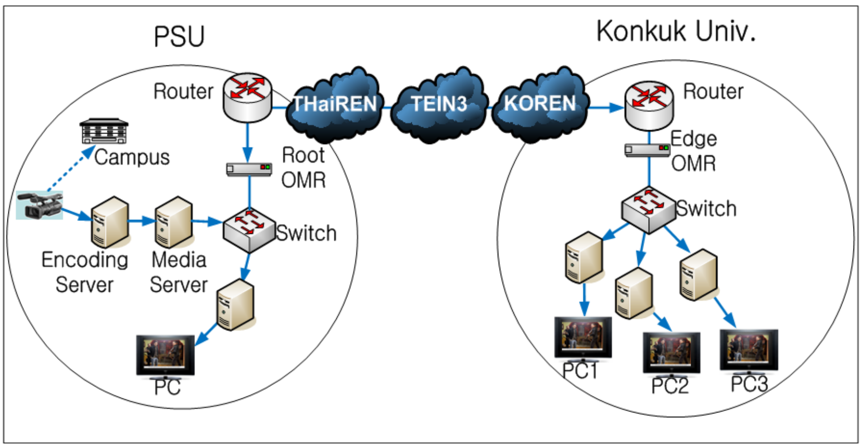

Fig. 4: Overlay Multicast Test-bed between KU and PSU

There is root OMR, a HD camera, an encoding server, a PC for check, and a media server in the PSU side. Between PSU and Konkuk Univ., there are three main networks ThaiREN, TEIN3, and KOREN, connect with each other. In Konkuk Univ. side there are edge OMR, and streaming checking PC1, PC2, PC3.

We send the university campus scene streaming by using HD camera or video file in the media server to make the real time streaming, and then forward the streaming data to an encoding server for encoding the streaming, and then forward the data to the root OMR through switch. It will be changed into the unicast data and forwarded to edge OMR through the three networks between PSU in Thailand and Konkuk University in Korea.

In edge OMR side of Konkuk Univ., when edge OMR gets the unicast video streaming from root OMR in PSU side, the edge OMR can change unicast data streaming to multicast streaming in the whole local network and then forward it to clients through switch. So the PC1 PC2 PC3 can get the streaming from PSU at the same time with same video quality.

In the experiment we analyze network performance with network tool called pathchar [1] when the overlay multicast streaming sending at the same time. This tool lets the user to find the bandwidth, delay, average queue and loss rate of every hop between any source and destination on the Internet [1]. The result is in the TABLE 1.

In the TABLE 1 there are some question marks, that mean the hop's bandwidth cannot be checked with pathchar network tools, because there are some limits setting in the router to obstruct the pathchar's ICMP message.

Table.1: Reslut of pathchar

IP Address \ time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
202.28.99.202	95	95	90	89	89	98	98	88	97	93	97	92	97	92	90	95
202.28.99.193	8.5	13	8	14	19	8.2	20	15	15	11	11	10	9.6	12	12	9.3
192.168.0.201	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
192.168.97.1	76	83	76	83	89	82	86	86	78	98	73	97	85	71	79	88
192.168.96.117	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	72
192.168.0.101	?	384	?	384	256	384	266	256	339	204	329	203	226	1877	113	?
202.28.221.21	?	?	?	?	?	832	?	?	?	?	?	?	?	914	?	193
202.28.218.77	3157	535	3187	555	?	2048	?	?	675	2319	670	2219	1587	309	1536	421
202.28.218.53	286	?	286	?	242	560	255	242	924	212	914	209	571	?	97	582
202.28.210.238	?	?	?	?	?	7936	?	?	5732	?	5632	?	996	11008	?	?
202.28.218.22	233	333	253	333	275	838	265	265	531	356	431	366	528	404	203	263
202.29.12.9	16	15	19	20	14	15	20	16	24	15	14	15	14	15	14	14
203.181.249.210	70	94	75	84	65	99	65	61	194	56	184	57	92	89	163	126
apii-e300-v1036.jp.apan.net (203.181.248.229)	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
koren-e300-v102.jp.apan.net (203.181.249.217)	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
116.89.178.167																

Although there is enough bandwidth as shown in official homepage of TEIN3, but at the experiment with the test-bed, the real time bandwidth of these two paths are shown in TABLE 1. We suppose that the bandwidth is not enough because traffic of the network at the experiment time was busy.

There are two paths bandwidth bottleneck explain in below. Path 1 is in the PSU between 202.28.99.202 router to 202.28.99.193 router, and the second bottleneck is from Japan to Singapore (202.28.218.22 to 202.29.12.9).

1) Path 1 (PSU : 202.28.99.193) Bandwidth from 8.2Mbps to 20Mbps.

Although there is no problem to forward 3Mbps or 7Mbps video streaming there could be problems when the 17Mbps streaming is sent. Therefore we should use the streaming which has smaller than 8.2Mbps size to forward in this path.

2) Path 2 (Japan- Singapore : 202.29.12.9) Bandwidth from 14Mbps to 24Mbps.

The bandwidth is not enough when forwarding the streaming with several channels at the same time. The data size is 20Mbps maximum because the data traverse through 202.28.99.193 then through 202.29.12.9 router. The same reason as path 1 we just can send the 14Mbps streaming which is not bigger than minimal bandwidth of this path.

Combine the path 1 and path 2 we should use 8.2Mbps streaming maximum for the experiment, so it will be working well.

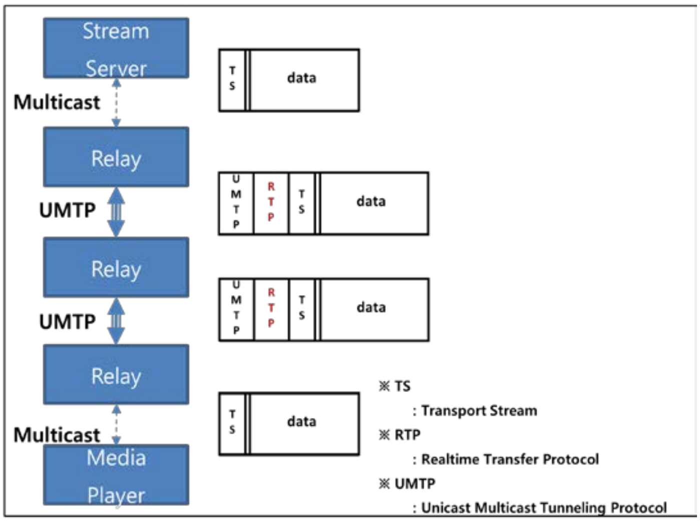

Fig. 5: Packet Structure of Streaming Data

QOS MEASUREMENT ANALYSIS

For QoS measurement value in test-bed we added the RTP protocol header between the TS (Transport Streaming) [14] header and UMTP (Unicast Multicast Tunneling Protocol) header of overlay multicast test-bed in Figure 5. Because the RTP protocol is built on the UDP protocol for inherent latency introduced by connection establishment and error correction, so we can compare the sequence number and the timestamp field as shown in Figure 6 of RTP protocol to get the latency and losing.

The Figure 6 shows the packet format of UMTP and RTP. Media server will add a TS header in front of the video data, and when video streaming comes from media server the video streaming will added UMTP header by the overlay multicast system, we will add RTP header based as this system in the root OMR side. If the video streaming is forwarded from root OMR to edge OMR the RTP protocol can record the time and the sequence number of the video data. So with this way we can compare the sequence number and timestamp record of root OMR and edge OMR to check the data loss and time latency.

UMTP header

```
typedef struct {
    u_char  stype;
    u_char  command;
    u_short mcast_port;
    u_int   mcast_addr;
    u_short src_cookie;
    u_short dst_cookie;
    u_int   length;
    u_int   src_addr;
} UMTPHeaderRaw_t;
```

RTP header

```
typedef struct
{
    u_int8     flags;     /* Version(2),Padding(1), Ext(1), Cc(4) */
    u_int8     mk_pt;     /* Marker(1), PlayLoad Type(7) */
    u_int16    sq_nb;     /* Sequence Number */
    u_int32    ts;        /* Timestamp */
    u_int32    ssrc;      /* SSRC */
    u_int32    *csrc;     /* CSRC's table */
} rtp_hdr;
```

Fig. 6: The Header of UMTP and RTP

By using the packet structure we make experiments and collect the experiment data with analysis. In Figure 7 there is the result of our experimental data with the RTP protocol record comparison. We just show two of results although we made it many times, because they can represent the whole experimental results.

Upper part of table in the Figure 7 the start sequence number is from 35 and the finish sequence number is 65. It shows that no loss sequence rate. Even more the Diff value of sender and receiver is 40. That means the sum of different value with sender sequence number and receiver sequence number. Average of Diff of sender and receiver is 1.290323. This value’s meaning is that network delay will be larger if Average_diff value is bigger. There will be the same relationship with network delay and the value of Average_diff when the value of Average_diff reduced. If the Average_diff value is 0, that means the network has a very good condition.

The below part of table in Figure 7, there is another result, it shows that the sequence number is from 66 to 95, the loss sequence rate is 0, diff value of sender and receiver is 42, and average of Diff of sender and receiver is 1.400000.

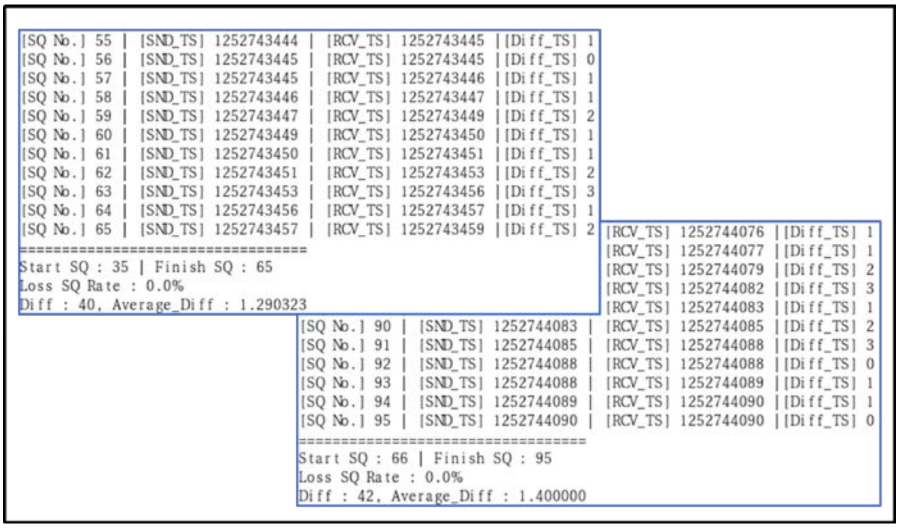

Fig. 7: Result of QoS Measurement with RTP

CONCLUSION

In this paper we use overlay multicast technology to construct a test-bed at international research network; we do several times of multicast QoS experiments in the test-bed network. Because of the characteristics of overlay multicast technology we can get the same multicast streaming at the same time. With these same video streaming we can get more exactly QoS measurement result.

To get the real time network bandwidth we use a network bandwidth checking tool called pathchar to check the network bandwidth before forwarding the multicast streaming in overlay multicast test-bed. With this bandwidth checking tool the network real time situation can be mastered by us, and we will know what kind of video streaming should be sent and do the QoS measurement more exactly.

In this paper we add the RTP protocol between the TS header and UMTP header of overlay multicast test-bed. To get the QoSmeasurement value we also use sequence number field and timestamp field of RTP header. We do several times comparing of sender side sequence number and receiver side sequence number to get the packetlosing and the data delay.
We get analysis and comparing result of QoS measurement with the experiment in international research network. We performed many performance valuation of multicast. We propose management solution and QoS measurement method of multicast video service in the international research network. Use the achievement of this paper we will do some relevant of QoE as future works, because the QoE is based on QoS but QoE has more abroad concept then QoS. Therefore this paper will become assistance for the future works.

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